

Depth of Knowledge

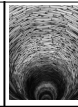


MaThink 3/30/13

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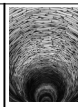
Depth of Knowledge



- Depth of Knowledge is the complexity or depth of understanding required to answer or explain an assessment related item.
- The concept of depth of knowledge was developed through research by Norman L. Webb in the late 1990's. Webb was a senior research scientist for the Wisconsin Center of Education Research.
- Webb originally developed depth of knowledge for mathematics and science standards. However, the model has been used in language arts, mathematics, science, and history/social studies.

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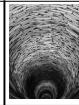
Why Depth of Knowledge?



- No Child Left Behind (NCLB) now requires states to align their assessments "with the depth and breadth of the state's academic content standards at all grade levels." (U.S. Department of Education, 2003, p.12)

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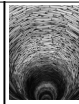
Connections Across Disciplines



- **Standards of Mathematical Practice**
 1. Make sense of problems and persevere in solving them.
 1. Asking questions (science) and defining problems (eng.)
 6. Constructing explanations (science) and designing solutions (eng.)
 9. Come to understand other perspectives & cultures.
 2. Reason abstractly and quantitatively.
 5. Using mathematical and computational thinking
 3. Construct viable arguments and critique the reasoning of others.
 7. Engaging in argument from evidence
 4. Comprehend as well as critique.
 5. Provide evidence.

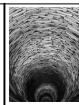
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Connections Across Disciplines

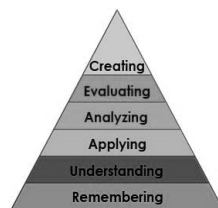


4. Model with mathematics.
 2. Developing and using models
 3. Planning and carrying out investigations
 4. Analyzing and interpreting data
5. Use appropriate tools strategically.
 5. Use technology strategically and capably.
6. Attend to precision
 8. Obtaining, evaluating, and communicating information
 2. Build strong content knowledge.
 6. Care about precision
7. Look for and make use of structure.
 7. Craft and look for structure
8. Look for and express regularity in repeated reasoning.

Bloom's New Taxonomy



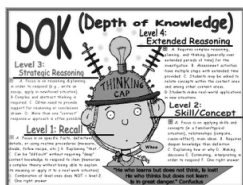
1. Remembering
 - Remembers or recall PK.
2. Understanding
 - Translates, comprehends, or interprets information based on PK.
3. Applying
 - Selects, transfers, & uses data and principles to complete a task or problem with minimum direction
4. Analyzing
 - Distinguishes, classifies, & relates the assumptions, hypotheses, evidence, or structure of a statement.
5. Evaluating
 - Appraises, assesses, or critiques on a basis of specific standards & criteria.
6. Creating
 - Develops new understandings through creating connections between ideas.



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Webb's Depth of Knowledge

1. Recall
 - Recalls facts, information, procedures, or definitions.
2. Basic Application of Skill/Concept
 - Uses information, conceptual knowledge, and procedures.
3. Strategic Thinking
 - Uses reasoning and develops a plan or sequence of steps; process has some complexity.
4. Extended Thinking
 - Conducts an investigation, needs time to think and process multiple conditions of problem or task.



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Compare and Contrast:

$$\begin{array}{r} 25 \\ + 86 \\ \hline \end{array} \qquad \begin{array}{r} 25,009,877 \\ + 86,998,354 \\ \hline \end{array}$$

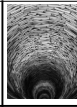
One is "harder" than the other, but they are both DOK 1.

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Hess' Cognitive Riger Matrix & Curricular Examples: Applying Webb's Depth-of-Knowledge Levels to Bloom's Cognitive Process Dimensions – M-Sol				
Revised Bloom's Taxonomy	Webb's DOK Level 1 Recall & Reproduction	Webb's DOK Level 2 Skills & Concepts	Webb's DOK Level 3 Strategic Thinking/Reasoning	Webb's DOK Level 4 Extended Thinking
Remember Retrieve knowledge from long-term memory; recognize, recall, locate, identify.	Recall, identify, & recognize facts, principles, procedures among representations or numbers (e.g., operations and mental computation).	Specify and explain relationships (e.g., non-reciprocal commutative rule effect). Make and record observations. Repeat what is observed. Summarize results or concepts. Make basic inferences or logical predictions from observations. Use models, diagrams to represent or explain mathematical concepts. Make and explain estimates.	Use concepts to solve non-routine problems. Explain, generalize, or connect ideas with mathematical relationships. Make logical inferences. Explain thinking when more than one response is possible. Explain phenomena in terms of concepts.	Rotate mathematical or scientific problems to other varied angles, other domains, or other settings. Generalize or connect ideas with mathematical relationships. Explain thinking when more than one response is possible. Investigate or research and report from new problem situations.
Understand Clarified meaning, clarify, paraphrase, represent, rephrase, explain, give examples, describe, compare, contrast, summarize, infer a logical conclusion (such as from experimental results), compare/contrast, make the connection, make the case, explain, construct, explain.	Understand an expression or locate points on a grid or number line. Make a simple problem-solving plan. Repeat what is observed. Summarize results or concepts. Make basic inferences or logical predictions from observations. Use models, diagrams to represent or explain mathematical concepts. Make and explain estimates.	Select a procedure according to circumstances and/or problem. Solve routine problem-solving multiple concepts or decision points. Repeat information from a table, graph, or figure and use it to solve a problem involving multiple steps. Translate between units, graphs, words, and symbolic notation (e.g., graph data from a table). Construct simple graphs.	Design investigation for a specific response or research question. Conduct a strategic investigation. Use concepts to solve non-routine problems. Use data, models, diagrams, etc., to solve a problem. Translate between words & symbolic notation when not a direct translation.	Select or devise approach among many alternatives to solve a problem. Conduct a project that specifies a problem, identifies solution paths, solves the problem, and reports results.
Apply Carry out or use a procedure in a given situation; carry out (apply to a familiar case), or use (apply to an unfamiliar case).	Follow simple procedures (step-by-step directions). Calculate, network, apply a rule, apply operations or formula (e.g., area, perimeter). Solve routine problems. Represent information using representations or numbers, or words and/or symbolic notation. Make and explain estimates.	Select a procedure according to circumstances and/or problem. Organize or order data. Compare and/or order data. Select appropriate graph and organize & transfer data. Repeat data from a simple graph. Extend a pattern.	Compare information within or across sets of data. Analyze and draw conclusions from data. Make logical inferences. Compare a pattern. Repeat data from a simple graph. Translate between words & symbolic notation when not a direct translation.	Select or devise approach among many alternatives to solve a problem. Conduct a project that specifies a problem, identifies solution paths, solves the problem, and reports results.
Analyze Break into constituent parts; determine how parts relate; determine how they function; determine how they are related; determine how they are related; determine how they are related; determine how they are related.	Analyze information from a table or graph to answer a question. Identify a pattern. Identify a pattern.	Select a procedure according to circumstances and/or problem. Organize or order data. Compare and/or order data. Select appropriate graph and organize & transfer data. Repeat data from a simple graph. Extend a pattern.	Compare information within or across sets of data. Analyze and draw conclusions from data. Make logical inferences. Compare a pattern. Repeat data from a simple graph. Translate between words & symbolic notation when not a direct translation.	Select or devise approach among many alternatives to solve a problem. Conduct a project that specifies a problem, identifies solution paths, solves the problem, and reports results.
Evaluate Make judgments based on criteria; weigh, select, compare, contrast, make the connection, make the case, explain, construct, explain.	Analyze information from a table or graph to answer a question. Identify a pattern. Identify a pattern.	Select a procedure according to circumstances and/or problem. Organize or order data. Compare and/or order data. Select appropriate graph and organize & transfer data. Repeat data from a simple graph. Extend a pattern.	Compare information within or across sets of data. Analyze and draw conclusions from data. Make logical inferences. Compare a pattern. Repeat data from a simple graph. Translate between words & symbolic notation when not a direct translation.	Select or devise approach among many alternatives to solve a problem. Conduct a project that specifies a problem, identifies solution paths, solves the problem, and reports results.
Create Develop new ideas, concepts, or products; determine how parts relate; determine how they function; determine how they are related; determine how they are related.	Analyze information from a table or graph to answer a question. Identify a pattern. Identify a pattern.	Select a procedure according to circumstances and/or problem. Organize or order data. Compare and/or order data. Select appropriate graph and organize & transfer data. Repeat data from a simple graph. Extend a pattern.	Compare information within or across sets of data. Analyze and draw conclusions from data. Make logical inferences. Compare a pattern. Repeat data from a simple graph. Translate between words & symbolic notation when not a direct translation.	Select or devise approach among many alternatives to solve a problem. Conduct a project that specifies a problem, identifies solution paths, solves the problem, and reports results.

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Depth-of-Knowledge Consistency

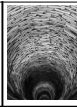


- Questions/Tasks must measure the degree to which the knowledge elicited from students on the assessment is as complex as what students are expected to know and do as stated in the standards.

CHALLENGE

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Claims of SBA



- Overall Claim
 - “Students can demonstrate college and career readiness in mathematics.”
- Claim 1 – Concepts & Procedures
 - “Students can explain and apply mathematical concepts and interpret and carry out mathematical procedures with precision and fluency.”
- Claim 2 - Problem Solving
 - “Students can solve a range of complex well-posed problems in pure and applied mathematics, making productive use of knowledge and problem solving strategies.”
- Claim 3 - Communicating Reasoning
 - “Students can clearly and precisely construct viable arguments to support their own reasoning and to critique the reasoning of others.”
- Claim 4 - Modeling and Data Analysis
 - “Students can analyze complex, real-world scenarios and can construct and use mathematical models to interpret and solve problems.”

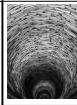
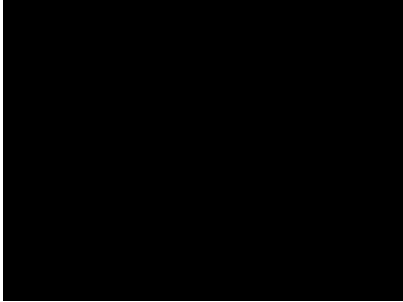
DOK and Rigor & Relevance



- Instruction, assignments, and classroom assessment must incorporate the expectation of rigor for students associated with the DOK levels of all objectives for that grade and content area.

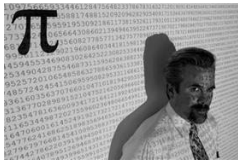
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Karin Hess



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Recall & Reproduction: Level 1



Marc Umile recited "pi" to 12,887 digits (March 2, 2006); A difficult task, but not complex.

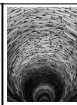
- DOK 1 requires recall of information, such as a fact, definition, term, or performance of a simple process or procedure.
- Answering a Level 1 item can involve following a simple, well-known procedure or formula. Simple skills and abilities or recall characterize DOK 1.



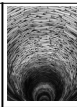
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Level 1 Recall - 4th grade

- Bill lives on the side of the street with even-numbered addresses. Which addresses below would be found on Bill's side of the street
- A. 1020, 1022, 1024
B. 2021, 2023, 2025
C. 3168, 3169, 3170
D. 4167, 4168, 4170



Level 1 Recall - 8th grade Math



- Example:
 - From any vertex of a 4-sided polygon, 1 diagonal can be drawn.
 - From any vertex of a 5-sided polygon, 2 diagonals can be drawn.
 - From any vertex of a 6-sided polygon, 3 diagonals can be drawn.
 - From any vertex of a 7-sided polygon, 4 diagonals can be drawn.
 - How many diagonals can be drawn from any vertex of a 20-sided polygon?



Level 1 Recall - 11th grade Math



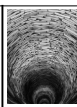
- The density of kerosene is approximately 0.82 g/mL.
 - Drag a rate or quantity from the box to each blank to calculate the mass, in kilograms, of 20 liters of kerosene.

___ 1 ___ × ___ 2 ___ × ___ 3 ___ × ___ 4 ___

20 L	820 kg	820 mL	2,000 mL
0.82 g	2000 mL	1 L	1,000 g
1 mL	20 L	1,000 mL	1 kg
1 kg	1 kg	1,000 mL	1,000 L
1,000 g	1,000 L	1 L	1 kg

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Skills/Concepts Level 2



- DOK 2 includes the engagement of some mental processing beyond recalling or reproducing a response. Items require students to make some decisions as to how to approach the question or problem.
- These actions imply more than one mental or cognitive process/step.

• The table below shows a linear pattern.

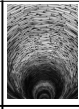
Term	1	2	3	...	n
Value	5	7	9	...	?

Which of the following expressions represents the value of the n th term in the pattern?

- A. $n + 2$
- B. $2n + 3$
- C. $3n + 2$
- D. $4n + 1$

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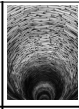
Level 2 Skills/Concepts - 4th grade Math



- The class went on a field trip. The students left school at 9:00 am, They returned to school at 1:30 p.m. How long were they gone?
A. 8 hr 30 min
B. 8 hr
C. 4 hr 30 min
D. 4 hr

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Level 2 Skills/Concepts - 8th grade Math



- Example:
- A triangle has 0 diagonals, a quadrilateral has 2 diagonals, a pentagon has 5 diagonals, and a hexagon has 9 diagonals. If the pattern continues, how many diagonals will an octagon have?

Sides	3	4	5	6
Diagonals	0	2	5	9

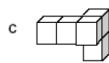
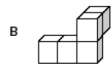
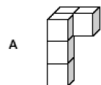
- A. 11
B. 14
C. 18
D. 20



Level 2 Skills/Concepts - 11th grade Math



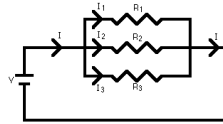
- Which pentacube is not congruent to the others?



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Strategic Thinking - Level 3

- DOK 3 requires deep understanding as exhibited through planning, using evidence, and more demanding cognitive reasoning. The cognitive demands at Level 3 are complex and abstract.
- An assessment item that has more than one possible answer and requires students to justify the response they give would most likely be a Level 3.



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Level 3 Strategic Thinking-4th grade

- Think carefully about the following question. Write a complete answer. You may use drawings, words, and numbers to explain your answer. Be sure to show all of your work.
 - Laura wanted to enter the number 8375 into her calculator. By mistake, she entered the number 8275. Without clearing the calculator, how could she correct her mistake?
 - Without clearing the calculator, how could she correct her mistake another way?

















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Level 3 Strategic Thinking-8th grade Math

- Look at the drawing. The numbers alongside each column and row are the total of the values of the symbols within each column and row. What should replace the question mark?

				28
				30
				20
				16
?	19	20	30	

24

- | | | | | |
|---|---|---|---|----|
|  |  |  |  | |
|  |  |  |  | 30 |
|  |  |  |  | 20 |
|  |  |  |  | 16 |
| ? | 19 | 20 | 30 | |

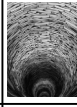
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- Level 4**
extended thinking
DESIGN
CONNECT
SYNTHESIZE
APPLY CONCEPTS
CRITIQUE
ANALYZE
CREATE
PROVE

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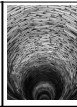
Level 4 Extended Thinking- 5th grade Math



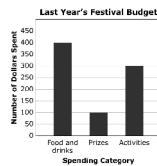
- **School Festival** You serve on a committee that is in charge of planning a school festival. The following tasks need to be completed by committee members as part of the planning for the school festival.
 - Determine the budget for the festival.
 - Choose the food and drinks for the festival.
 - Determine amounts of supplies for making a dessert.
 - Make a schedule of the different activities.
 - Make some decisions on the games and prizes used during the festival.

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Level 4 Extended Thinking- 5th grade Math



- Part A : Money to Spend
- Part B: Food and Drinks
- Part C: Make the Dessert
- Part D: Schedule of Activities
- Part E: Games and Prizes



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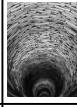
Level 4 Extended Thinking- 8th grade Math



- Read Information about the activity, Water Tank or Water Tower

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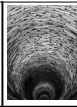
Level 4 Extended Thinking- 11th grade Math



- Players A and B are playing a game. On a table between them is a stack of n pennies. First, Player A removes either one or two pennies from the stack. Then Player B removes either one or two pennies from the stack. They alternate in this way until no pennies remain. The loser is the player who removes the last penny from the stack.
 - If they start the game with 5 pennies in the stack, how many pennies should Player A take from the stack on her first turn? Why?
 - If the game starts with 7 pennies in the stack, would you rather be Player A or B? Why?
 - For what values of n , if any, is it best to be player A?
 - For what values of n , if any, is it best to be player B?
 - Explain and justify your answers.

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What is the DOK Level?



1. Multiply two 4-digit numbers.
2. Specify a problem, identify solution paths, solve the problem, and report the results.
3. Locate or recall facts found in text
4. Solve multi-step problem and provide support with a mathematical explanation that justifies the answer
5. Gather, analyze, organize and interpret data from multiple (print and non-print sources) to draft a reasoned report
6. Compare the graph of a quadratic equation with the graph of a line.
7. Determine the area of a triangle given a drawing or labels
8. Classify plane and three dimensional figures

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